Acoustic Mortar Localization System – Results from OIF

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ABSTRACT

The US Army Research Laboratory developed and deployed an acoustic mortar and rocket detection and locating device, in a little over two months. After receiving a direct request from Iraq, ARL merged components from a number of programs to enable the rapid fielding of this capability. As of mid 2004, four Unattended Transient Acoustic MASINT Systems (UTAMS) have been operated detecting mortar fire, rocket launches and IED's while displaying the localized results. Due to the typically high angle of flight of mortar fire, the acoustic signal of the launch can arrive at the array before the mortar impact. This can provide a short time for advance warning. Results were so successful that the Multi-National Corps – Iraq (MNC-I) generated an Operational Needs Statement (ONS), in addition CJTF76 has requested UTAMS units for Afghanistan. A portable Acoustic Mortar Detection System (AMDS) has also been developed in support of SOCOM. This version is lightweight, low-power, air-deployable and automated for mortar launch detection.

1. INTRODUCTION

ARL has studied the problem of mortar detection for some time in investigating impulsive signal detection and long range acoustics. Explosions create wide band signals; those generated by artillery can contain low enough frequencies that will propagate very long ranges. The mortar signature is somewhat specialized because of its low amplitude and the mortar tube itself. Using low cost hearing aid microphones configured in a tetrahedral array (Fig. 1),

Fig. 1 – Tetrahedral Microphone Array

battlefield activity like mortar fire, rocket launches and IED detonations can be detected. By exploiting existing COTS based hardware and ARL developed algorithms and signal processing, we were able to make minor modifications to existing designs and deliver operational equipment directly to the field.

2. COMPONENTS

Acoustic array configurations had been studied and were in existence. It became our task to match a configuration to an existing 24-bit A/D that we could purchase off the shelf. The application of the 24-bit A/D to this problem is significant in that the large available dynamic range can handle very low amplitude (long range) signals as well as near, very loud sounds. Combining this with COTS extended temperature range single board computer, operating under a real-time operating system, and a viable platform could be delivered. This hardware was selected and the packaging designed for extended temperature range application. The package consisted of an environmental enclosure that was selected to keep its internal temperature below the upper limit of the extended temperature range electronics at outside temperatures that would likely be encountered in Iraq. By deploying multiple arrays (up to four) at each site, and wireless connectivity between the arrays and a laptop computer, lines of bearing from the arrays to the source can be created. At the location where these lines-of-bearing (LOBs) cross is a potential target source.

3. SIGNATURE

The mortar launch signature is predominantly in the 100 Hz region, while the impact signature contains more energy and wider frequency content. Automatic signal identification is being implemented to allow the signal processing to indicate which signal is a point of origin (POO) and which is a point of impact (POI) (Fig 1). Detection ranges for each of the various types of mortars is typically accomplished at the tactical range of the weapon. UTAMS has demonstrated that it detects both POOs and POIs. It is more difficult to detect the POO since it comes from a further distance and contains less energy.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
00 DEC 2004	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Acoustic Mortar Localization System Results from OIF	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **US Army Research Laboratory Adelphi, MD 20783**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM001736, Proceedings for the Army Science Conference (24th) Held on 29 November - 2 December 2004 in Orlando, Florida., The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**2**	

4. ALGORITHM

The detection algorithm is based on sufficient coherent energy (energy weighted by coherence at each frequency) across the full array. An adaptive filter adjusts for the acoustic background and enhances the ability to find impulsive events in the time waveform. Once an event is detected that passes the coherent energy level requirement an angle of arrival is developed from the timings across all of the microphones. Statistics from the content of the detected signal suggest whether the detection is a valid acoustic wave.

5. DISPLAY

Using a standard mapping package LOBs are displayed over a map or overhead imagery of the area around the array location. The tracking algorithm evaluates the LOBs and where they cross to determine whether the detections are likely to be acoustic signals and if so plots an icon over the crossing. This is shown in Fig. 2 below.

Fig. 2 – Display of a Launch and Impact

The tracking algorithm will remove ghosting and crossings that could not have been created by acoustic signals. A log of the LOBs is kept on the laptop computer where it can be reviewed at a later time and replayed through the display to recreate the display and localized results. Once a detection is reported, the user can click on the LOB and view the time waveform generated. This allows the user to evaluate visually if the signal was in fact a mortar, rocket an explosion or something else of no interest.

6. PERFORMANCE

UTAMS has demonstrated useful accuracies, though it is not intended to be a counter battery device. While high winds will degrade system performance and temperature inversions during the heating of the day will shorten detection range, the wide spectral content of the explosive launch and impacts tend to ease the detection problem. The relatively short range of mortars and small rockets also tends to be favorable to the UTAMS detection range.

7. RESULTS

Through the assembly of off the shelf components and commercial hardware ARL has successfully delivered acoustic mortar and rocket detection capability to the soldier. Up to four sites have been operated in Iraq detecting and locating insurgent mortar and rocket fires. Success can be judged by the formal request for more UTAMS units in Iraq and additional units for Afghanistan. We have quantified the performance capabilities and can provide the classified performance capabilities upon request. A classified briefing was presented at the recent MSS Battlefield Acoustics and Seismics Conference and is referenced below. The availability of AMDS as a low power light weight mortar and rocket detection device offers additional capability for SOCOM.

ACKNOWLEDGEMENT

This capability could not have been delivered without the aid of many individuals in ARL's Acoustic Signal Processing and Sensor Integration Branches. In particular, Lenora Isaiah-Weathers was the driving force in assuring the assembly of each of these sets of UTAMS units.

Also, without MAJ Greg Holifield's original request for the device and his ability to successfully present the concept to other soldiers in active combat and sell them on it, we would not have been successful. His original vision encouraged all of us to bring the technology forward. His replacements, MAJ Marcus Varnadore and MSG Mark Brzezinski, were important in covering the second wave of training and maintenance. And finally the soldiers in the field who have operated UTAMS and provided feedback to us are invaluable in their contribution. May they stay safe and all return home.

REFERENCE

Tenney, S. M., 2004: Unattended Acoustic Masint System (UTAMS) (SECRET), Military Sensing Symposium, Battelfield Acoustic And Seismic.